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Self-starting all-polarization maintaining Yb-fiber laser with a polarization maintaining anomalous dispersion higher-order-mode fiber

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All-integrated modelocked Yb-fiber lasers are very attractive for a wide range of potential applications, including micromachining, spectroscopy, metrology, nonlinear imaging and several clinical applications. The adoption of these lasers beyond laboratory environments is hindered because of the sensitivity of modelocking operation against external perturbations. In non-polarization maintaining (non-PM) fibers, temperature changes, fiber bending and other mechanical perturbations, can influence the birefringence properties of the fibers which can result in degradation of device performance and eventually losing of modelocking. Since environmental instabilities in fiber lasers mainly arise from induced changes in the birefringence of non-PM fibers, the straightforward approach to make the laser robust against them is to use PM fibers with light polarized only along the slow axis [1,2]. A major challenge to develop operational and environmentally stable fiber lasers delivering high fidelity femtosecond pulses at 1 µm wavelength is to realize good higher order dispersion compensation and to manage intracavity nonlinearities.

Previously we have demonstrated a high-fidelity oscillator in which dispersion compensation was realized with a higher order mode fiber (HOM) [3], but this scheme was based on non-PM fibers. Several environmentally stable Yb-fiber oscillators using PM fibers and different approaches for dispersion compensation has been realized. Such approaches include using bulk gratings [1], chirped PM-fiber Bragg gratings [4], solid core PM-photonic crystal fibers [5]. Recently the realization of a PM-higher order mode fiber (HOMF) was demonstrated [6]. The use of a HOMF has key advantages over the other approaches. It allows for smooth intracavity compensation including higher order dispersion without introducing severe nonlinearities in the system. Additionally, integration of solid silica-based HOMF is possible using standard fusion splicing techniques.

In this contribution we demonstrate a semiconductor saturable absorber mirror (SESAM) modelocked all-polarization maintaining femtosecond fiber laser where for the first time a PM-HOMF has been used for intracavity dispersion compensation. The layout of the oscillator ring cavity is shown in Fig. 1 (left). The mode-locking mechanism is based on a SESAM. The gain medium was a 40 cm long highly Yb-doped PM fiber (Yb-401 PM from Coractive). The oscillator repetition rate is 10 MHz. The total cavity dispersion is slightly anomalous and the oscillator operates in the weak stretched pulse regime. It delivers 1.2 nJ pulses that can be externally recompressed down to 150 fs. The output spectrum and corresponding pulse are shown in Fig. 1 (center) and (right), respectively. For our proof-of-principle setup we have made use of a configuration including free space components but straightforward realization of an all PM-fiber integrated system is possible with commercially available PM fiber based components.

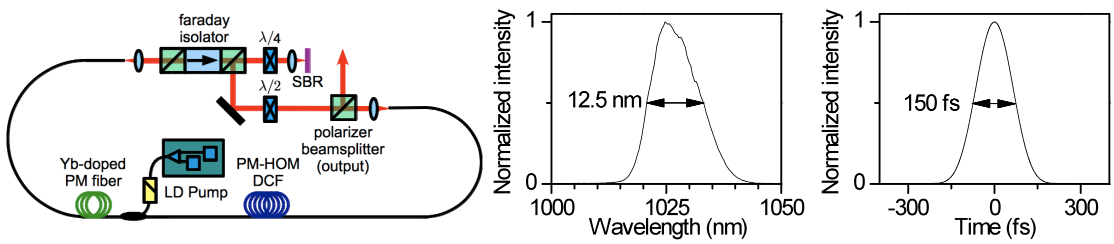

Fig. 1 (left) Oscilltor schematic, (center) output spectrum and (right) corresponding pulse shape.

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